Tuesday July 20 : 9am, CMS mtg room 6th floor hirise

Jet Triggering at D-Zero

- Typical triggers used
- Efficiencies - what kind?
- Various ways to measure (Data/MC)
- Some measurements and closure
- Some complications

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DØ Run1 Jet Triggers

The DØ Run1 trigger consisted of “three” stages: in Run II

- •Level Ø (LØ) beam hodoscope L0
- •Level 1 (L1) Trigger Towers(TT) (0.2 x 0.2 in η x φ) and L1
Large Trigger Tiles(LT) (0.8 x 1.6 in η x φ) at fixed positions
- •Level 1.5 (L1.5) DSP clustering of trigger towers L2
- •Level 2 (L2) jet clustering (fixed cone) around L1 seed jets L3

Typical single jet trigger configurations:

name	L1 terms	seed term	L2 terms
Jet_12	1 TT>2 GeV		12 GeV
Jet_20	1 TT>3 GeV		20 GeV
Jet_30	1 LT>15 “	1 LT>6	30 GeV
Jet_50	1 LT>35 “	1 LT>6	50 GeV
Jet_85	1 LT>60 “	“	85 GeV
Jet_115	1 LT>60 “	“	115GeV

Fast readout/
coarse sampling

high precision
readout

Jet Trigger Efficiencies

Single Jet Efficiency - Probability for a given jet to pass trigger
Event Efficiency - Probability for event to pass trigger

for single jet triggers: Event Efficiency > Single Jet Efficiency

Trigger efficiencies may be estimated a number of methods:

1) normalization/matching method: take data w/ Less Restrictive Trigger (LRT) - minBias is best! - normalize your distribution to LRT well above threshold. Works great, but takes HUGH piles O' data.
2) single jet ⇒ event efficiencies: measure single jet efficiencies - translate into event efficiencies based on topology of your favorite events
3) Monte Carlo - Just Simulate it!  (is this a dominant error?)

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Data vs. MC measurements

Data-based efficiency measurements:

+ All electronics effects are perfectly modeled - they're in there!
+ Can easily match Luminosity, reconstruction and scale parameters between Trigger Data and Evaluation Data
- Difficult to acquire large unbiased samples
- May be difficult to turn limited data measurements into a global efficiency for events w/ complex topology
- No Pjet level information

MC-based efficiency measurements

+ can easily equate efficiencies w/ particle-level physics objects
+ can generate exact topologies you are interested in
- detector hardware effects (ie. noise, resolution from electronics,…) may be very difficult to model precisely
- overlay of Noise/Additional events is big/cumbersome project to match data sample

Single Jet Efficiencies In DØ Data

Two stage trigger L1 + L2 : eff = eff(L1) * eff(L2|L1)

L1 efficiencies: found by comparing L1 objects in trigger of interest w/ those in less restrictive trigger (LRT)

$$E_{jet}^{L1}(E_T^{jet}) = \frac{\text{\# of Denominator Jets w/ L1 requirement satisfied}}{\text{All Jets passing LRT}}$$

Note: reconstruction effs. assumed 100%

L1 REQ (GeV)	Seed REQ (GeV)	LRT REQ (GeV)	L1 Efficiency
1TT>2	1 TT >2	1TT>0 (MB)	TT(1,2) | MinBias
1LT>6	"	1LT>0 (MB)	LT(1,6) | MinBias
1LT>9	"	1LT>6 (LRT)	LT(1,9) | LT(1,6) *ε(LT(1,6))
1LT>15	"	1LT>9 (LRT)	LT(1,15) | LT(1,9) *ε(LT(1,9))
1LT>20	"	1LT>15(LRT)	LT(1,20) | LT(1,15) *ε(LT(1,15))
1LT>25	"	1LT>20(LRT)	LT(1,25) | LT(1,20) *ε(LT(1,20))

Level 2 Single Jet Efficiencies

$$E_{jet}^{L2|L1}(E_T^{jet}) = \frac{\text{\# of Denominator Jets w/ L2 requirement satisfied}}{\text{All Jets passing L1 Trigger}}$$

This efficiency is determined for each trigger with one of two data sets:

- Special Mark and Pass runs (apply trigger and mark passing jets, but write all events to tape)
- On Line Monitoring events (‘Pass 1 of N’ events in all data runs no matter the result at L2)

Advance planning necessary to collect necessary data, especially if measurements are to match the run's luminosity profile

Event Efficiencies

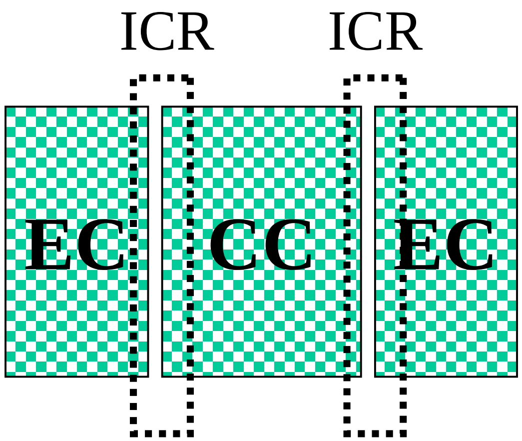
Single Jet to event efficiencies are a little tricky.
Jets are usually not required to 'trace' in order to satisfy the trigger.

i.e. A jet 'traces' if it satisfies all levels of the trigger. It is quite possible that one jet can satisfy L1 and another will satisfy L2, especially near thresholds.

Why not make jet triggers traceable?

3) possible time/data constraints preclude matching of objects
2) can cause big efficiency loss in multi-jet triggers
(annoys top/higgs folks + everybody w/ small acceptance/rate
1) softens slope of trigger turn on curve v. ET
i.e. INCREASES data rates, more inefficient events to tape

Event Efficiencies



Consider a 2-jet event:
each jet may be in EC, CC, or ICR
different effs. expected in each region,
detector differences, physics differences

6 combos: CC-CC, CC-ICR, CC-EC,
ICR-ICR, ICR-EC, EC-EC

Event eff. measurement for all possible topological combos, requires too much data

More general solution is to measure single jet eff as function of ET/pseudorapidity and combine to get event effs. For a particular analysis

Combining 1-Jet Effs and Ambiguities

Single Jet effs. may be combined for all jets in an event to get event efficiencies.

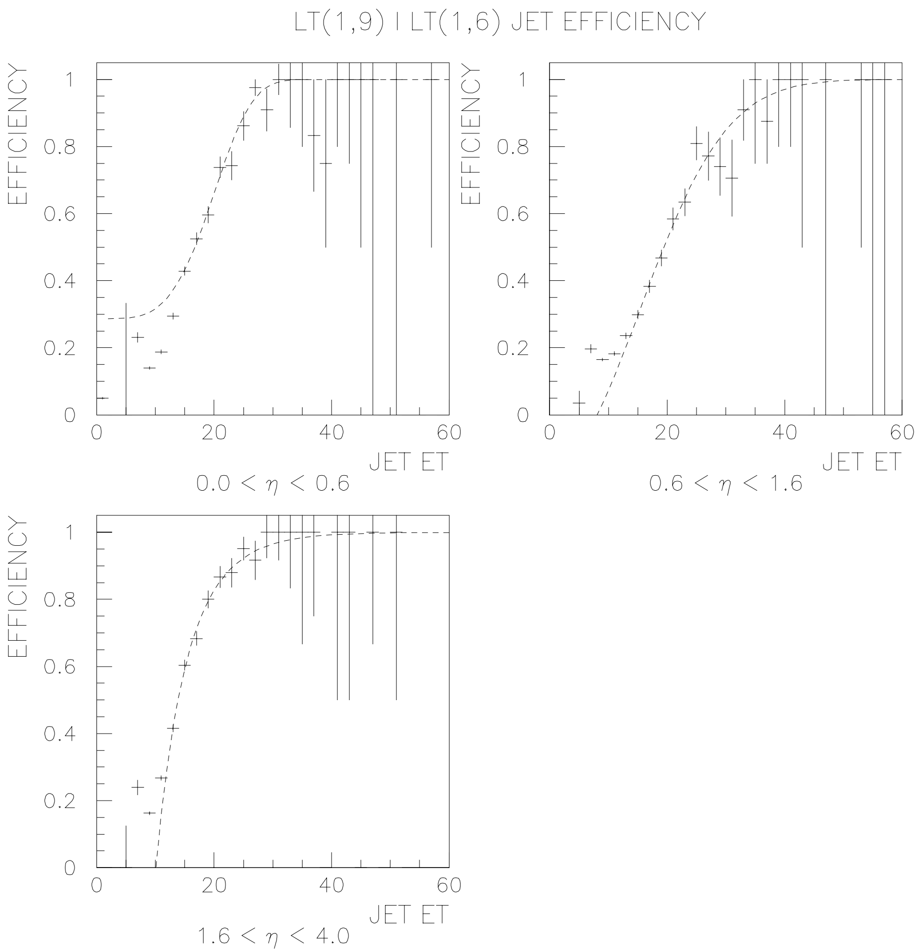
Basically take 'OR' for all jets in the event to pass the trigger
- however certain approximations are typically necessary -
namely correlations between a jet firing different level triggers
or correlations between one jet firing the trigger and another doing so

Consider:

ET of interest	ET of a second jet in same event
35 GeV	13 GeV
35 GeV	35 GeV
35 GeV	80 GeV

Does each 35 GeV jet have equal efficiency?

Efficiency Curves



Low ET trigger
L1 effs.

All plots are versus reconstructed jet ET unless stated otherwise

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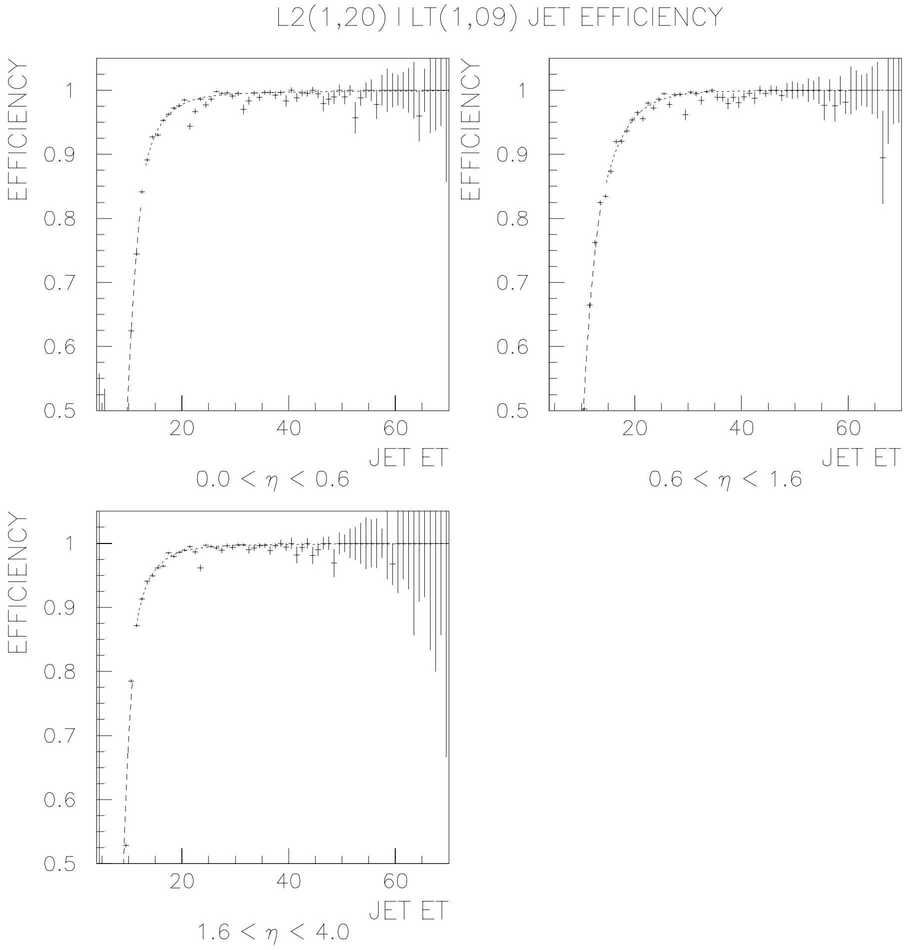
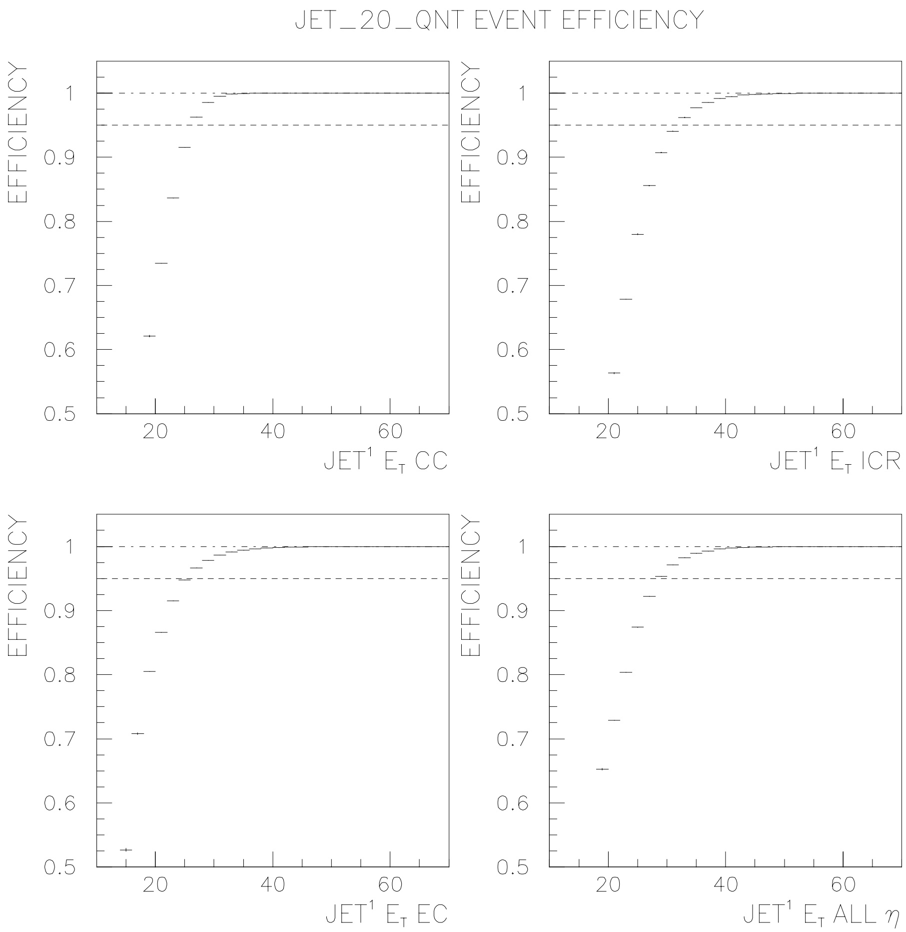
Efficiency Curves



Low ET trigger
L2 effs.

Efficiency Curves



Low ET trigger
L1*L2 effs.

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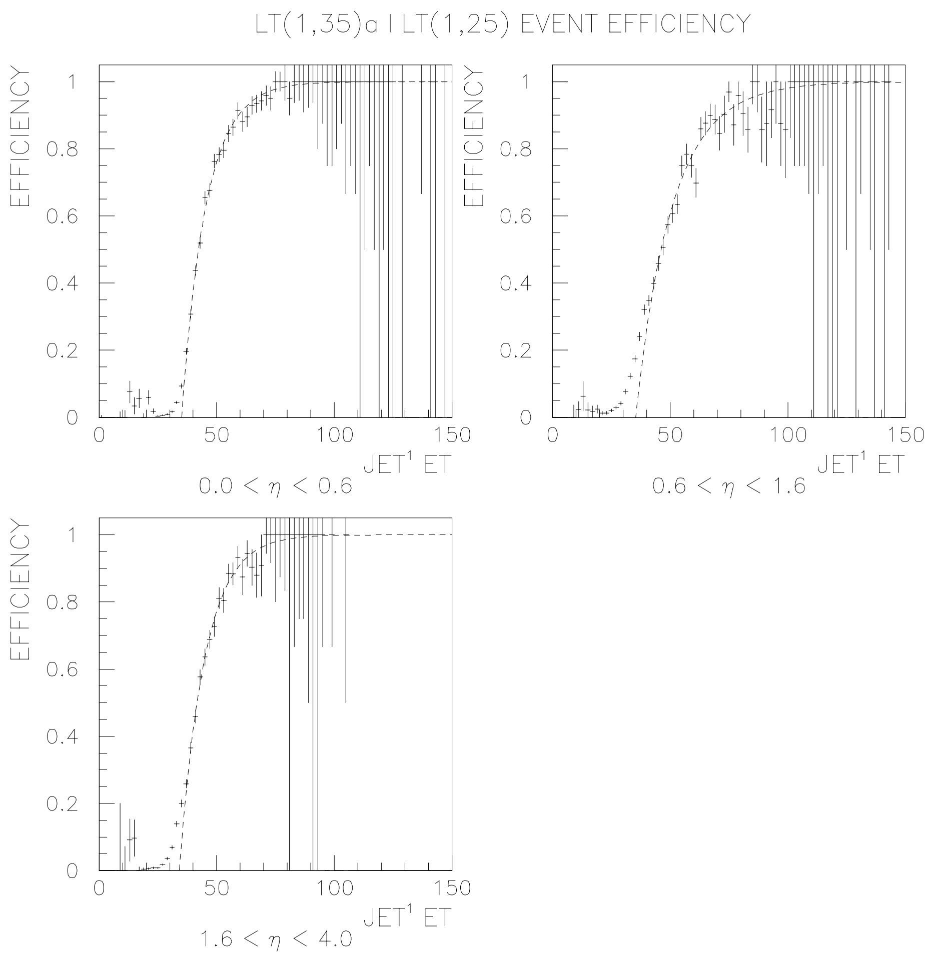
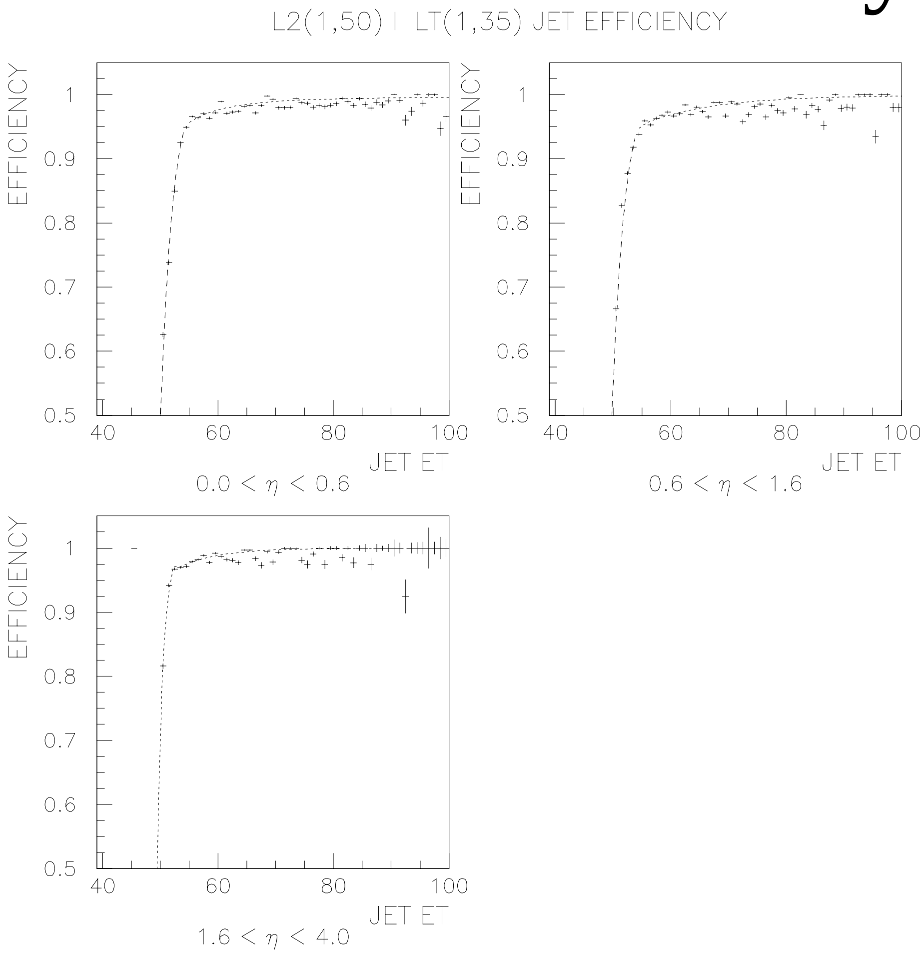
Efficiency Curves



High ET trigger
L1 effs.

Efficiency Curves



High ET trigger
L2 effs.

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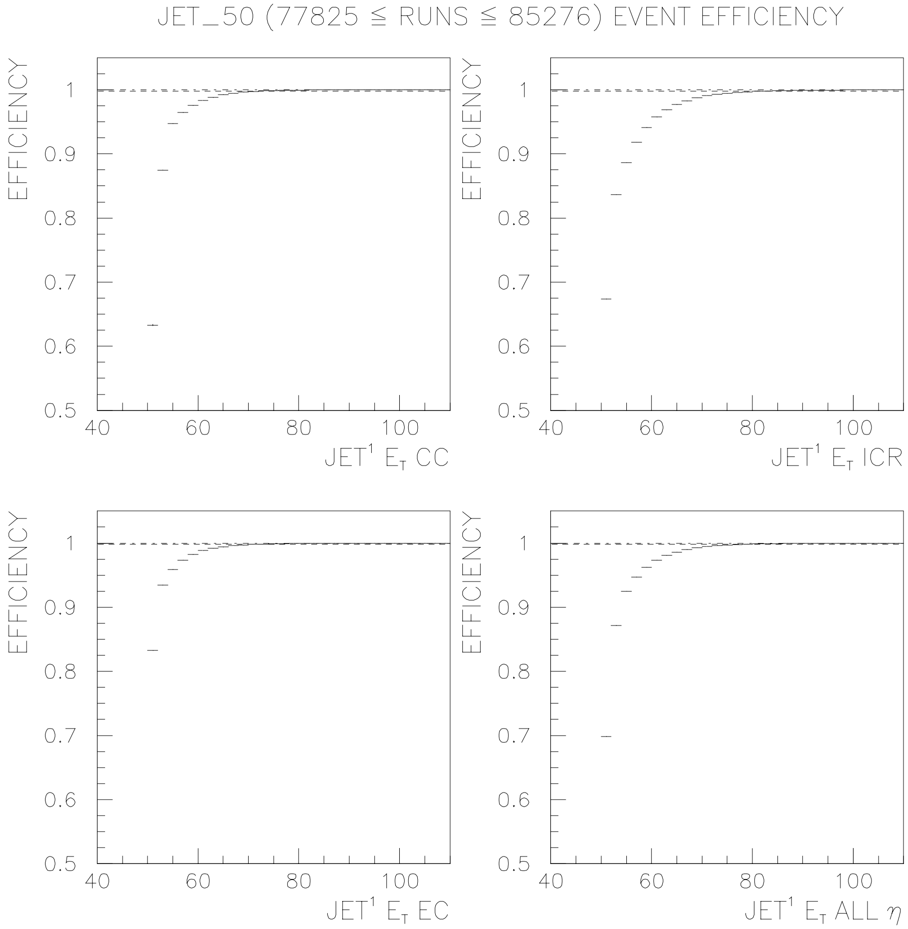
Efficiency Curves



High ET trigger
L1*L2 effs.

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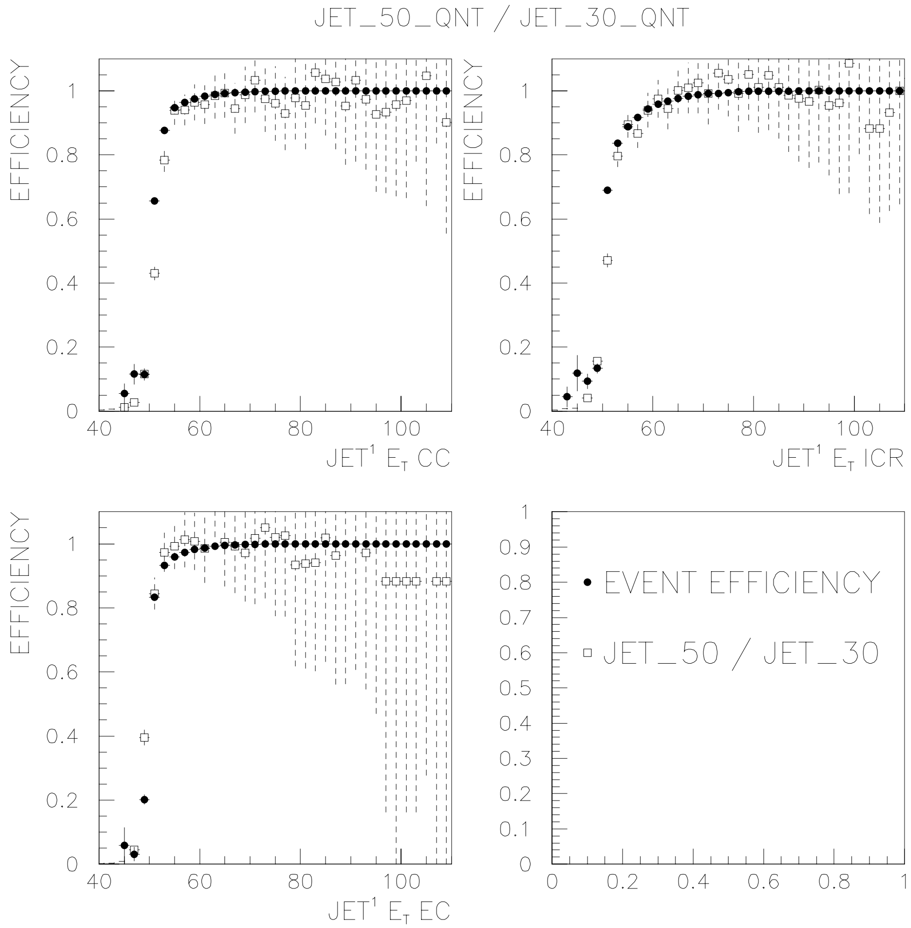
closure



High ET trigger closure

low lum special runs

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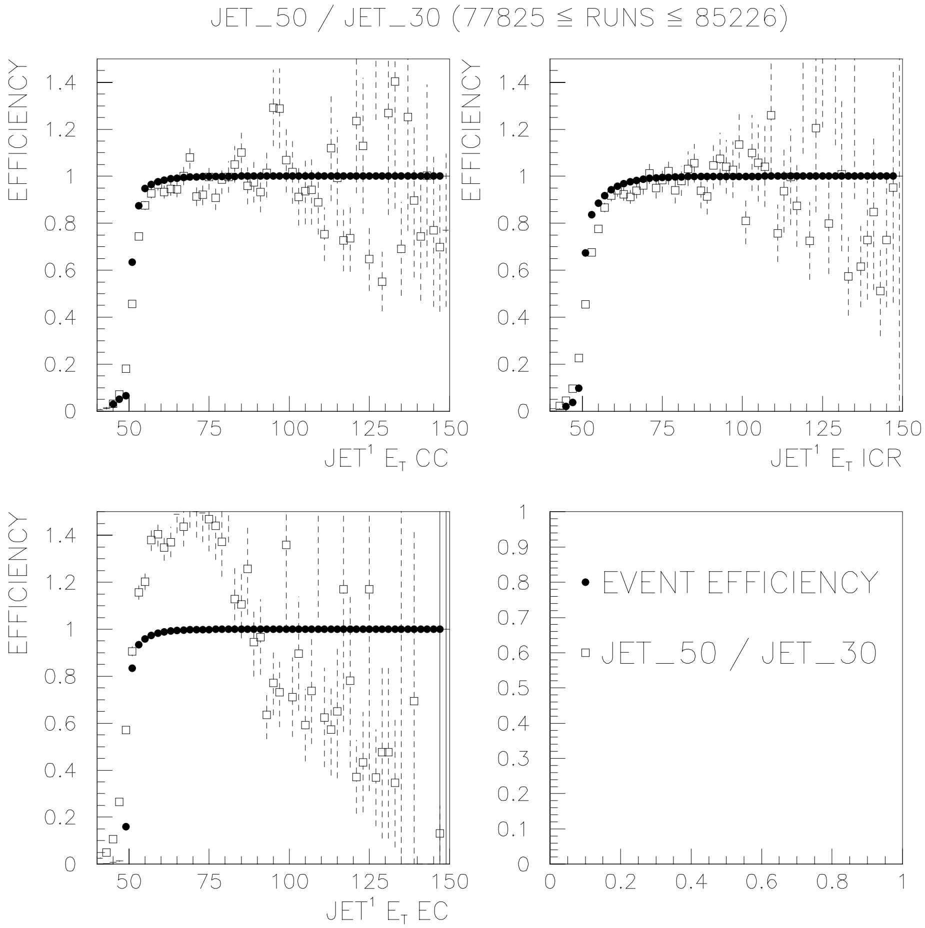
closure



High ET trigger
closure

global runs

Overshoot
in EC means that
50 GeV threshold
trigger finds more jets
than 30 GeV threshold
this is Lum effect of
added interactions +
some mis-vertexing

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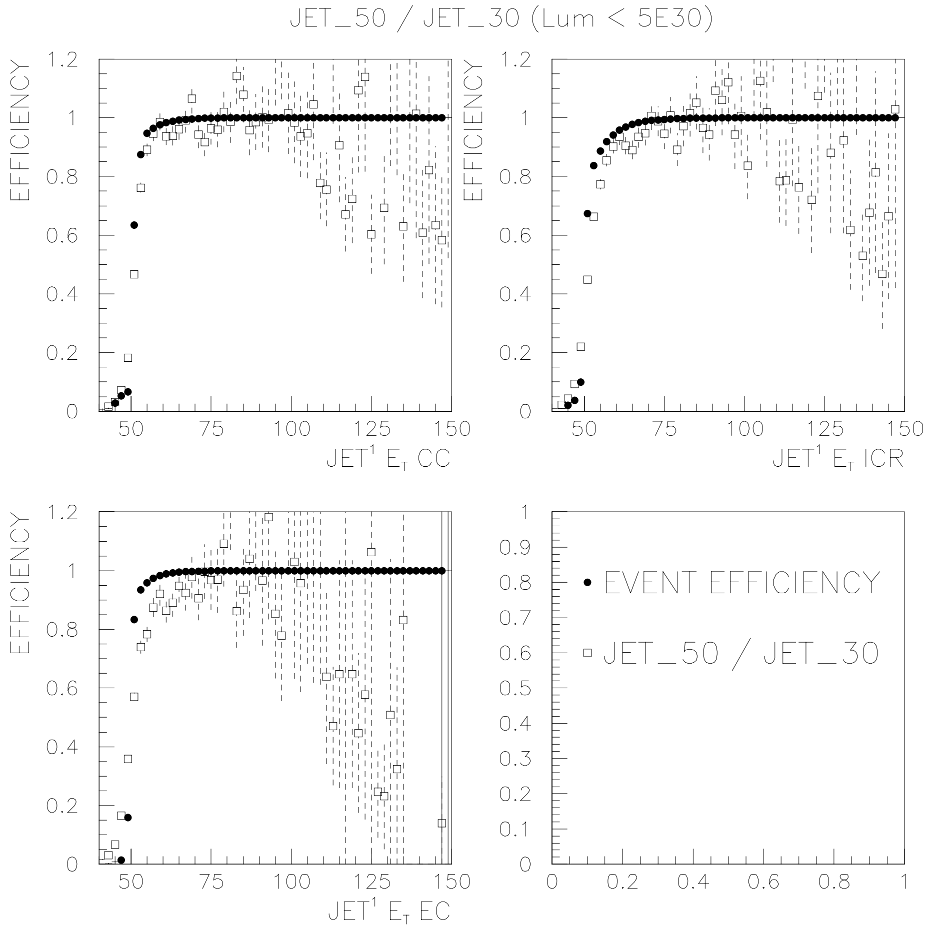
closure



High ET trigger closure

global runs + luminosity cut

Luminosity cut on 50 GeV thresh. data improves agreement

effs. are ALWAYS luminosity dependent

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Systematics

- Jet correlations (can get uncertainty estimates from MC)
- Narrow jets typically at threshold - low eff. Jets are NOT
  representative of whole jet sample
- Luminosity can matter a lot
- Radiated jets and leading jets needn't behave the same way
  just ask LEP - use most appropriate jet sample in eff.
  estimate
-

It's a slippery slope down to low efficiencies!
Must weigh increased uncertainty against increased sample size.

Efficiencies from MC

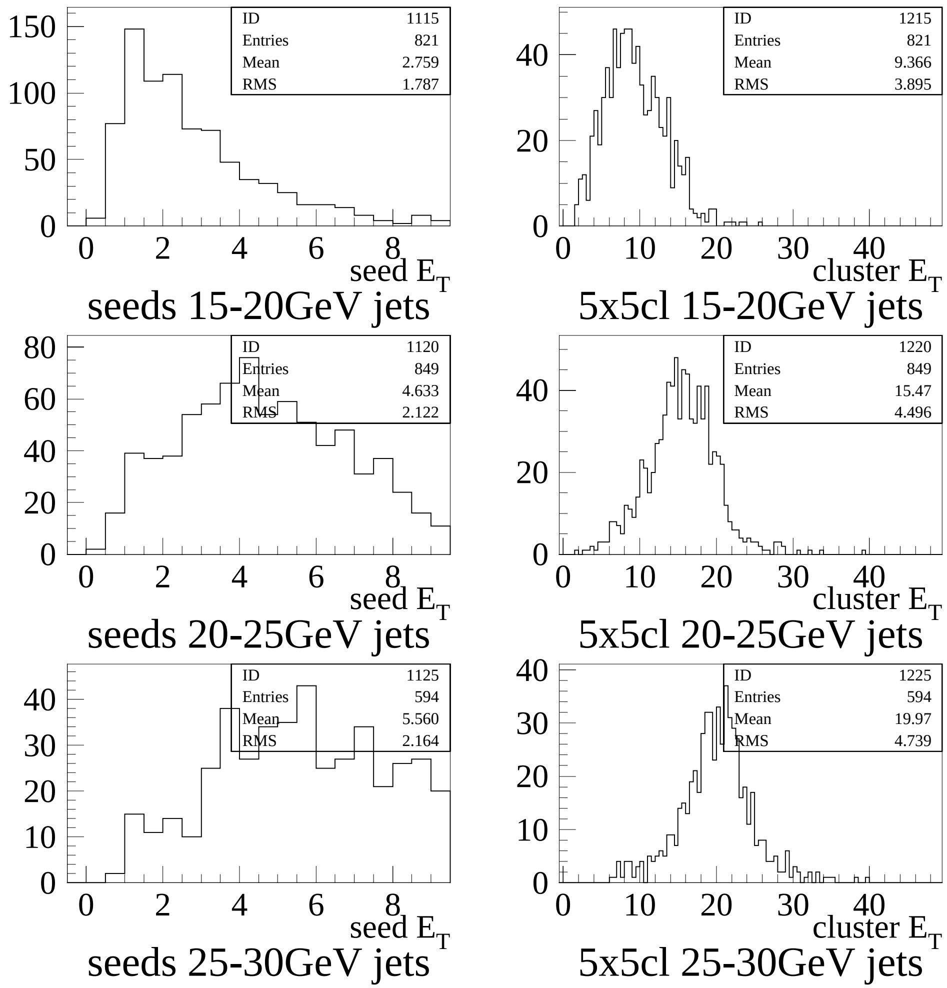
Can we do it all w/ MC????

MC does good job of modeling gross characteristics of jets, but small errors in very sensitive parameters will get you into trouble and it generally does a bad job of modeling your electronics

Consider:

- Fast read out trigger may very well have a different effective energy scale from precision readout
- Electronics may be different. How long is cable ganged into a trigger tower or region??? Resolution/scale issues….
- Jet core is very important in triggering/ how well does MC really model those messy nuclear interactions???

Fast Changing Regions



Small scale and to a lesser extent resolution modeling errors in MC - can have big effects on efficiencies!

P.S. # of multiples and electronic noise are effective offsets to scale + zero sup. effects

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MC is very valuable however in choosing relative quality
if triggers before running. Sharpen the trigger turn on at all costs!

Complex topologies will often require MC-based corrections

in this case extensive tuning is necessary for a precise measure,
be careful about confusing energy deposited in GEANT w/ energy
read into trigger electronics.

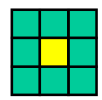
Choose appropriate data samples to tune MC and/or make
complimentary measurements.

For example:
a) calibrate MC to data - use single particles to get scale
b) realistic noise models for MC
c) use raw data to get map from precision readout to fast readout,
   don't just gang channels in MC

D0 RunII Level2 Clustering -- Cluster TT's in α CPU's before going to precision readout...

Addition of L2 Trig. Tower clustering to L1 tower triggers can offer large rate reductions with small cost in efficiency...

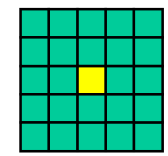
3 = 3x3 cluster



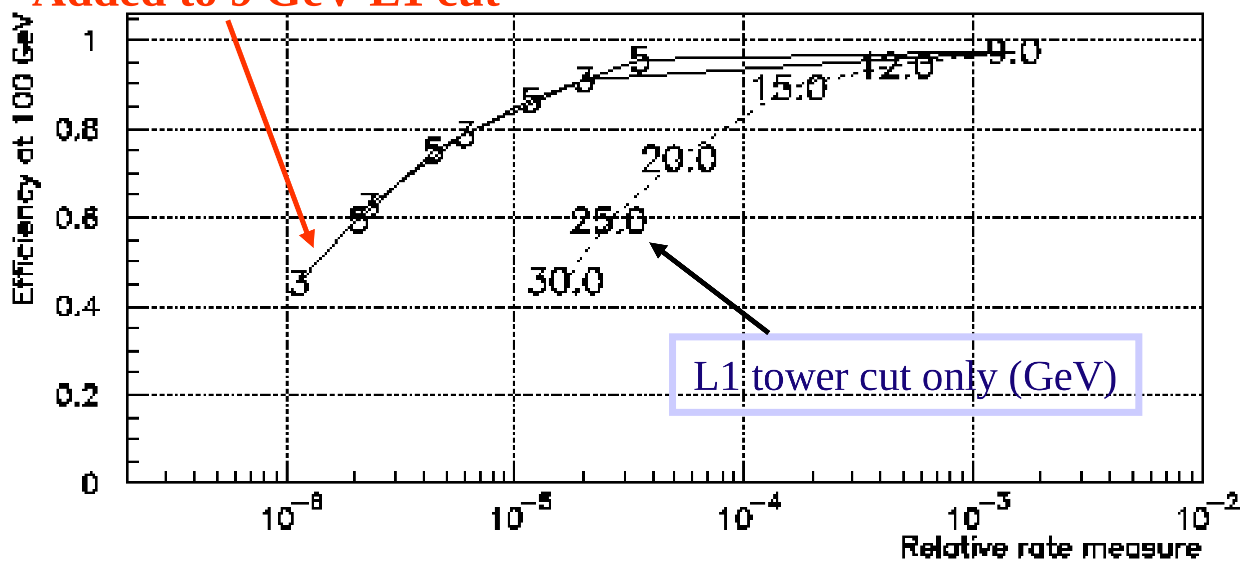
Eff. vs Rate at 100 GeV

(pjet ET)

5 = 5x5 cluster



L2 thresholds (1,60)(1,50)(1,40)(1,30)(none)
Added to 9 GeV L1 cut



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Conclusions

Jet Efficiencies - mean something different to every analysis
there is no ONE efficiency

Systematics are tricky - but even if precise eff. measurements are elusive, it is possible to get a good handle on where your plateau

Data based methods can match luminosity profiles, detector quirks, and higher order QCD effects well.

MC methods can offer convenient measures for complex topologies, careful systematic studies necessary to quote uncertainties.

Choose wisely!

Some DØ choices: INC CS 1800 GeV - use 100% eff. Data
INC CS 630 GeV, 1800 GeV Dijet Mass - jets >~95%
TOP/NP - typically MC based, complex topologies, other dominant errors

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